Filling a Box with Gas

Consider an ideal gas at temperature T, and a perfectly insulating box with a small hole of area A, which is closed for time t < 0. At t = 0, the hole is suddenly opened, and at a very small time $t = \tau$ later, the hole is closed again.

(a) Suppose that τ is small enough that almost no atoms have a chance to travel back out of the box. Show that in this case, after the box is closed and the internal gas is allowed to come to thermal equilibrium, the temperature T_{box} of the gas inside the box is given by

$$T_{\rm box} = \frac{4}{3}T.$$

(b) Estimate the time scale τ_0 over which the approximate T_{box} from the previous part will begin to be a bad approximation.